U. S. DEPARTMENT OF AGRICULTURE
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INFECTIOUS ANEMIA
(SWAMP FEVER)

INFECTIOUS ANEMIA is widely distributed and results in serious loss of horse and mule power in certain regions of the United States. There are also some losses through death. The disease is prevalent in many foreign countries as well as in this country.

Although this disease is known extensively as swamp fever, this name is not desirable as it is used also for malarial fever, a human disease caused by a parasite. Infectious anemia is caused by a virus which is present in the blood, body tissue, and body secretions of affected animals. Transmission of the infection from affected to healthy animals is believed to result from contaminated pastures or from biting insects which have fed on affected animals.

There are two principal forms of the disease. The chronic form is most common and is characterized by intermittent fever, loss of weight and strength, marked depression, and swellings on the under surface of the body and on the legs. The disease may appear also in the acute form, which is rapidly fatal. Still another or latent form produces no clinical symptoms, but the animal is a carrier of the infection.

There is no preventive vaccine known to be of value for infectious anemia; neither is there any treatment that will cure the disease. However, the usefulness of an affected animal can be prolonged by supportive treatment prescribed by a veterinarian. The available means of controlling this disease consist in protection against biting insects and preventing the infection from reaching healthy animals through contaminated feed and water. In areas where the disease is prevalent, its ravages can be held to a minimum by attending to sanitary conditions, furnishing abundance of feed, controlling parasites, and eliminating any factors that might exert a debilitating influence on the animals.

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INFECTIOUS ANEMIA (Swamp Fever)

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DISTRIBUTION AND PREVALENCE

INFECTIOUS ANEMIA, or swamp fever, is a specific, infectious disease that has long been recognized, having been reported from Europe as early as 1843. It has a wide geographical distribution, occurring in various parts of Europe, South Africa, Japan, Canada, and the United States. The disease has been authentically reported from the following 24 States: Arkansas, Colorado, Florida, Idaho, Illinois, Indiana, Kansas, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New York, North Dakota, Oregon, Tennessee, Texas, Utah, Virginia, Wisconsin, and Wyoming. Infectious anemia is of considerable economic importance in the Mississippi Delta where the disease has become established among the mules on the large cotton plantations. In this area the disease exists principally in the chronic form, saps the strength of the animals, and renders them incapable of regular work in the busy, cotton-growing season when they are most needed.

The disease is probably more widespread than the reports indicate. Doubtless it has not been recognized because of the difficulty of diagnosing the chronic and inapparent forms of the disease. In the inapparent form, there are no clinical symptoms, and the animal appears normal and eats in a normal manner, yet continuously harbors infection. Generally speaking, infectious anemia is most prevalent in poorly drained, low-lying sections, but it has been found at altitudes as high as 7,500 feet. The disease appears to be more prevalent when biting insects are most numerous; and during wet years more than in dry seasons. The active form of the disease makes its appearance in May or June, reaches its height in midsummer, and declines

[1] Resigned, October 1938.

late in the fall. Chronic cases may be seen in the winter, and it is possible to produce the disease experimentally at any time.

CAUSE

Infectious anemia is caused by an infectious agent known as a filtrable virus. In the lower animals the disease occurs in the horse, mule, and ass only. Infection in man has been reported in several instances, but it is probable that man is not very susceptible to the disease. The infectious agent is apparently present in the blood and body tissues of affected animals at all times and may be eliminated with any of the secretions and excretions. The disease can be readily transmitted experimentally to equines (horses, mules, and asses) by inoculation beneath the skin or into the blood stream, of whole blood, blood serum, spleen, brain, or other tissue emulsions. The infectious agent passes through diatomaceous-earth filters that will remove all visible or cultivatable forms of organismal life, such as bacteria, trypanosomes, and piroplasmata.

Transmission from diseased to healthy animals has been accomplished experimentally with the stable fly (*Stomoxys calcitrans*) and other insects. In a recent experiment conducted by the Bureau of Animal Industry the disease was transmitted by intimate stable contact in which the animals intermingled unrestrained in a large stable, drank from a common watering trough, and fed from the floor. In this experiment insects were controlled by tight screening of all windows and doors, and the entrance to the building was equipped with a double-compartment, screened vestibule. In the experience of the Bureau's investigators the disease did not spread from infected to normal animals when they were kept in adjacent stalls or adjoining box stalls, and water and feed were supplied from individual containers. Definite information is lacking, however, concerning the mechanism of infection in the natural state. Some investigators believe that the disease is spread principally while the animals are at pasture where the virus-laden urine and feces of an infected animal contaminate the feed and water of the healthy animals, but the part that biting insects play while animals are at pasture cannot be ignored.

FORMS

Infectious anemia may occur as an acute, rapidly fatal disease, or what is more common, as a chronic affection characterized by intermittent attacks of fever, loss of weight, progressive weakness, marked depression, and dropsical swellings on the lower portions of the body and on the legs. The disease may also exist in a form in which no clinical symptoms are observed, yet the animal so affected carries virulent virus in the blood stream at all times.

In the acute form of the disease, the incubation period following the subcutaneous injection of infected blood is usually about 12 to 15 days. However, it may vary from less than a week to 3 months and possibly longer. The onset is sudden and is manifested by a rise in temperature which usually reaches about 105° F. but may reach 108°. Respiration is accelerated and frequently is of the abdominal type. The animal is dejected, the head hangs low, leg weakness is marked (fig. 1), the body weight is shifted from one

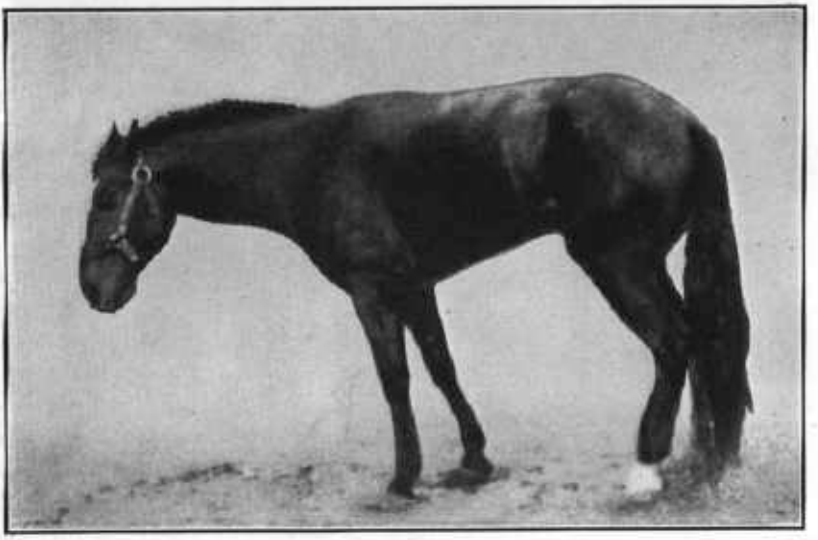

FIGURE 1.—Horse affected with the acute form of infectious anemia, showing extreme weakness of hind quarters.

leg to another, and the hind feet are frequently placed well forward under the body. The membranes of the eye show congestion, followed by brownish to yellowish discoloration. Feed is refused. The attack usually lasts from 3 to 5 days, after which the temperature returns to normal, and the animal appears to be well, except for a marked loss of weight.

Occasionally, however, the initial attack may persist until the animal dies. Dropsical swellings of the sheath, the legs, the breast, and under surfaces of the body may occur at any time (fig. 2). These frequently disappear and appear again at the same or other places. Subsequent attacks usually follow, with intervening periods of normalcy varying from a few days to many weeks or months. When the intervals between the attacks of fever are short the animal seldom lives more than 15 to 30 days. During the attacks of fever and immediately afterward, there is a destruction of red blood corpuscles, usually 1 to 1½ million per cubic millimeter. The red-

corpuscle count in exceptional cases has been noted to fall to 3 or 4 million per cubic millimeter. When the reduction of red corpuscles is pronounced, it can be readily demonstrated by drawing blood into a test tube in the bottom of which a small amount of powdered potassium oxalate or other anticoagulant has been placed to prevent clotting. A little agitation of the test tube during the drawing of the blood and immediately afterward in the presence of the anti-

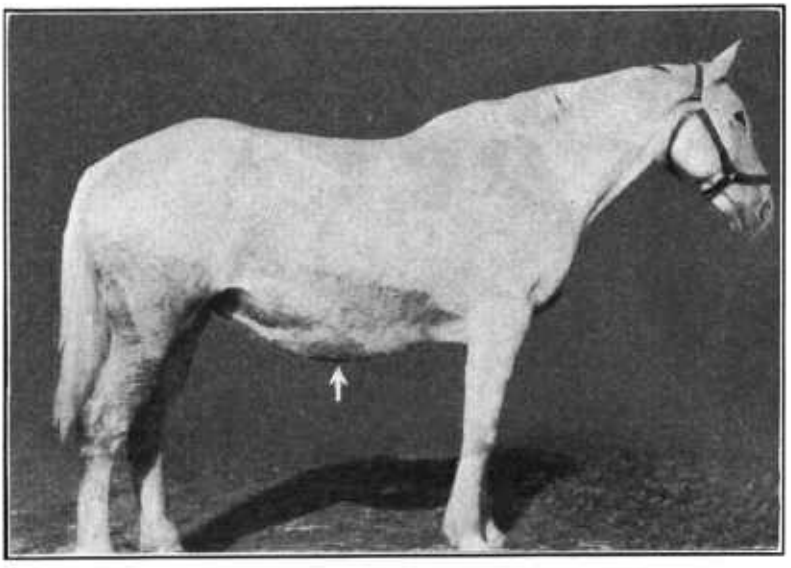

FIGURE 2.—A case of the subacute form of infectious anemia, showing extensive dropsical swellings (shown by arrow) on the abdomen.

coagulant will prevent clotting and permit the red corpuscles to gravitate to the bottom of the tube. A comparison of the sedimented red corpuscles with a sample similarly drawn from a normal horse will clearly demonstrate the degree of anemia that exists. In addition the supernatant serum will occasionally exhibit a greenish hue. During the periods of normalcy, between the attacks, the red-corpuscle count is in a great majority of cases normal.

The subacute and chronic forms of the disease differ from the acute in that the attacks are less severe and the intervals between the attacks are longer. It is not uncommon in the chronic form of the disease for the affected animals to remain in apparently good physical condition and to be capable of a considerable amount of work in the periods between the attacks of fever. In general, however, the chronic form of the disease is manifested by unthriftiness, rough coat, loss of weight, sluggishness, weakness, dropsical swellings of the lower parts of the body or on the legs, muddy discoloration of

the visible mucous membranes and small hemorrhages on the nictitans membrane (haw) and the nasal septum. In this form of the disease the appetite is unimpaired for the most part and frequently is ravenous so that the animals may be observed to be eating continuously if they have access to feed. In spite of an excessive consumption of feed, however, there is a progressive loss of body weight (fig. 3). It is this chronic form of the disease that is most commonly seen in the Mississippi Delta, and the damage is principally one of heavy

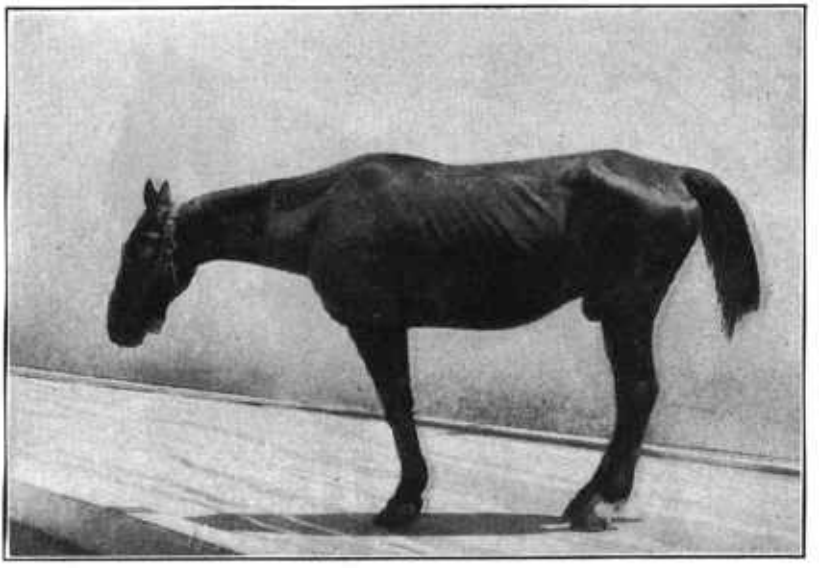

FIGURE 3.—Horse affected with infectious anemia in the chronic form. Note the poor condition resulting from infection.

losses of mule power during the cotton-growing season, when the services of the animals are most urgently needed.

Animals affected with this form of the disease can perform some work if handled with care. They are subject, however, to recurring attacks characterized by extreme weakness, knuckling, inability to walk in a straight line, and prominent hemorrhages on the nictitans membrane. The weakness may become so great that the animal cannot stand without support. With good attention, rest, and supportive treatment, the animals usually overcome these periodic attacks and may go back to their routine work. Each attack takes its toll of flesh and strength, however, and repetitions, if frequent enough, will so weaken the animals as to render them useless or finally bring about death by exhaustion. The North Dakota Agricultural Experiment Station reported a horse affected with the chronic form of swamp fever that lived for 14 years and, as 18 horse-inoculation tests showed, was infectious during the entire period.

The inactive or latent form of the disease may follow the first attack, but usually it is preceded by several attacks of fever. In this form of the disease no clinical symptoms can be observed in the affected animal. The temperature remains normal, no reduction in the red corpuscles takes place, and a complete absence of any sign of disease will extend over a period of years. Yet all the while the infectious agent is present in the blood stream and all the tissues and may

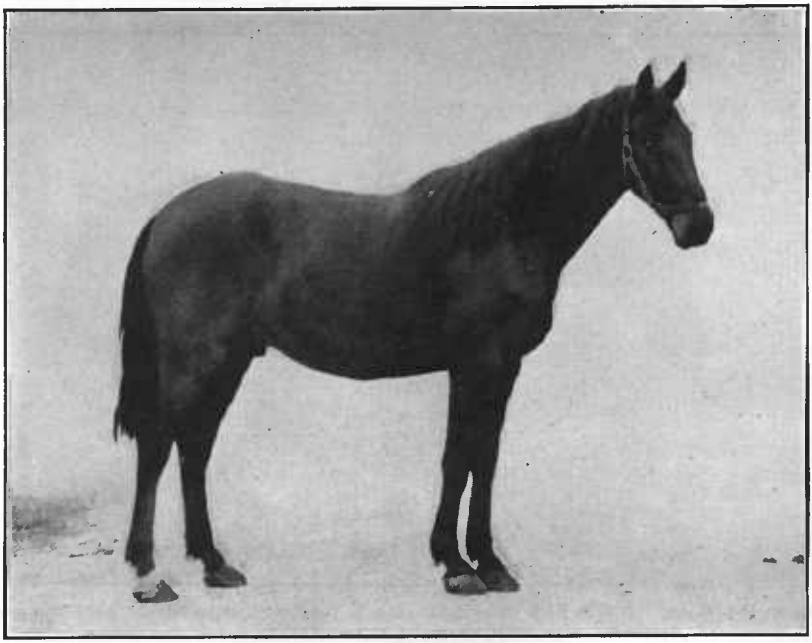

FIGURE 4.—A case of the inactive or inapparent form of infectious anemia. Although apparently in good health, this horse still carried the virus of infectious anemia, 2 years after the original infection.

be eliminated with the body excretions. Such animals obviously are dangerous and are a menace to other horses near them since they are veritable reservoirs of infection that for the most part go unrecognized and uncontrolled. The inactive form of the disease may, however, become active at any time, and present all the characteristics of the acute or subacute form of the disease. Unusually hard work or any debilitating influences may reactivate the inactive form.

The Bureau of Animal Industry had an experimental horse which was a good example of the inactive form of infectious anemia (fig. 4). This horse was exposed to the disease August 2, 1935, by being given an injection of filtered blood from two horses known to have infectious anemia. After an incubation period of 12 days, a typical attack of fever occurred, which in turn was followed by two more attacks

within a 3-week period. No further attacks occurred in this horse over a period of approximately 2 years. During this time this animal remained in good physical condition and showed no symptoms of disease whatsoever. Ten normal horses were injected with blood from this animal October 4, 1935, and nine of these succumbed to infectious anemia within 31 days after inoculation, and one developed the disease in chronic form and remained alive and in good condition for 21 months, when it was destroyed. Blood drawn from the experimental horse and injected into a normal horse on December 3, 1937, produced infectious anemia in the latter, indicating the continued infectiousness of the animal suffering from the inactive form of the disease.

The Wyoming Agricultural Experiment Station reported a case of infectious anemia produced experimentally in an 18-year-old horse. This animal, although continuously infected with the disease, as proved by horse inoculation tests, lived to be 33 years old.

ANATOMICAL CHANGES

The changes in the body tissues resulting from infectious anemia are variable. They may be extremely well marked and plainly visible, or may be so slight as to escape detection by those who have not had considerable experience with the disease. For the most part the changes found in the acute cases are more extensive and more pronounced than those in the chronic cases. The most constant gross changes are hemorrhages on the serous and mucous membranes of the body, with enlargement and other changes of the spleen, kidneys, liver, and heart. The hemorrhages are most frequently found on the pericardial sac, the pleura, covering the lungs and the surface of the ribs, the peritoneum, the mucous membrane of the small and large intestines and cecum, and the surfaces of the spleen and kidneys. The spleen is frequently enlarged and soft. Occasionally it will be found to be approximately three times its normal size, and the splenic pulp will be soft and dark red. The liver is often enlarged to enormous proportions and is hard and friable. The surface sometimes presents a mottled appearance as a result of areas of degeneration that are lighter in color. Occasionally hemorrhages are seen beneath the capsule of the liver. On cross section, the lobules of the liver stand out quite prominently and the cut surface is light in color. The kidneys are frequently enlarged, watery, and lighter in color than normal and present numerous hemorrhages on the surface, ranging in size from that of a pin point to several millimeters in diameter. The heart is usually enlarged, flabby, lighter in color than normal, and may present hemorrhages on the surface, in the muscle wall, and on the inner surface of the heart muscle forming the heart

cavities. The heart fat frequently loses its normal consistence and color and becomes soft and gelatinous. The visceral lymph glands may be enlarged, watery, and impregnated with hemorrhages. Large hemorrhagic areas are frequently seen in the marrow of the long bones, especially the femur. The marrow is softer than normal and in some instances becomes gelatinous. A yellowish discoloration of connective tissues and fat may also be evident. In some cases the anatomical changes are so pronounced as to make a striking picture, but, as previously stated, the lesions are quite variable and may occur in any combination.

DIAGNOSIS

Diagnosis of infectious anemia is for the most part a difficult matter since there are no symptoms or post mortem changes that can be considered characteristic and peculiar to this disease alone. The only definite means of diagnosis is by horse-inoculation test. Considering collectively the history, clinical symptoms, and blood examinations, diagnosis with a reasonable degree of accuracy can possibly be made in the active form of the disease. For example, a history of rapid loss of flesh, loss of spirit and energy, evidences of muscular weakness with intermittent attacks of fever, congestion of the mucous membranes of the eye, with possibly some degree of jaundice, and dropsical swellings of the lower parts of the body, collectively, are strongly suggestive of infectious anemia. The tentative diagnosis will be further strengthened if during and immediately after the febrile period an examination of the blood shows a diminution in the volume of the red corpuscles, an increased rate at which they gravitate, and a decrease of hemoglobin. It must be remembered, however, that in the intervals between the attacks of fever the blood picture promptly returns to normal. In practically all the Bureau's experimental cases, the diminution in the red corpuscles, that is, the anemia, was but transitory, and the corpuscle count returned to normal in the intervals between the attacks of fever even to the last. A few cases were observed, however, in which the anemia was of the progressive type. In one instance the corpuscle count rapidly and progressively diminished until the low level of 1½ million red corpuscles per cubic millimeter was reached.

Infectious anemia in the inactive form would ordinarily not be detected since no clinical symptoms would be present to cause suspicion. It should be remembered also that heavy infestation with intestinal parasites, especially strongyles, produce symptoms that are in some respects similar to those of infectious anemia. Microscopic examinations of the feces for the eggs of these parasites and

examination of blood films for evidence of eosinophilia will assist in making a differential diagnosis. It is possible, and in some areas probable, that some horses and mules will have heavy infestation with intestinal parasites and at the same time will be affected with infectious anemia in the chronic form. For further information on strongyle and other intestinal parasites of horses, the reader is referred to Circular 148, Parasites and Parasitic Diseases of Horses.

No laboratory test has yet been found that is specific and at the same time dependable for detecting all affected animals.

CONTROL MEASURES

Preventive vaccination has been attempted by a number of investigators, including those in the Bureau of Animal Industry. In the investigations conducted by this Bureau none of the tissue vaccines prepared from whole blood, blood serum, emulsions of spleen tissue, or emulsions of brain tissue in which the virus was destroyed by formalin, crystal violet, phenol, phenyl mercury acetate, and heat had any appreciable immunizing value.

In searching for an effective treatment many investigators have tried numerous agents such as arsenic preparations, quinine, various dyes, mercurial preparations, and a number of others, but without success. The Bureau experimented with merthiolate, crystal violet, trypan blue, sodium cacodylate, hydrochloric acid, potassium permanganate, fuadin, sulphanilamide, and other preparations, using both acute and chronic cases for these tests. None of the preparations, however, exerted any appreciable influence on the course of the acute disease, nor did any free the chronically infected animals of the virus. Since no specific medication has yet been found for the disease, treatment of affected animals is limited to symptomatic medication, rest, abundance of good feed, and the elimination of intestinal parasites or any other debilitating influences that may be operating.

No instance is known, however, in which an animal proved to be infected with swamp fever ever made a complete recovery with a disappearance of the virus. So far as is known, an animal, when once infected, is always infected. There are instances on record in which horses remained infectious, as proved by horse-inoculation tests, for periods of 14 and 15 years following experimental infection. Because of the fact that there is no definite practical means of diagnosis for the detection of chronic carriers of swamp fever, no systematic program of control can be undertaken.

With the knowledge that the disease may exist in the inactive form and that such animals carry the contagion in the blood stream at all times, the greatest care should always be used to prevent transmis-

sion of the disease from animal to animal by unsterilized instruments, bleeding needles, or even hypodermic needles. Until such time as a practical means of diagnosis becomes available and definite information is obtained on the mechanism of infection in the natural state, sanitary measures constitute the best known means of controlling infectious anemia. In those areas where there is reason to believe that many animals are affected with the disease in either a chronic or an inapparent form, the maintenance of good sanitary conditions, systematic control of parasites, attention to the feed, care, and handling of animals will help to hold the ill effects of the disease to a minimum.

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